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STEREOSPECIFIC ADDITION OF LITHIUM DIPROPENYLCUPRATE TO 2-CYCLOHEXENONE

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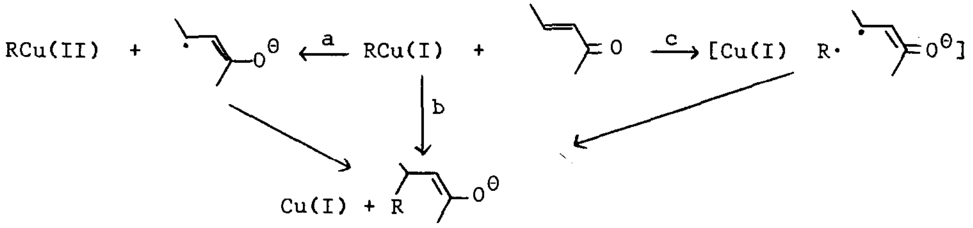
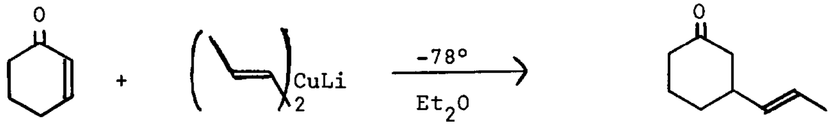
The mechanism of the conjugate addition of organocopper(I) compounds to α,β-unsaturated ketones is uncertain. A six center transition state is not a requirement for the reaction since the addition of lithium dimethylcuprate to trans-3-penten-2-one gives 69% of the trans enolate.[1] Free alkyl radicals are excluded as intermediates by the observation that isoprene does not interfere with organocopper conjugate additions.[2]

House and Fischer[3] have postulated that the reaction proceeds via electron transfer from the organocopper(I) species to the conjugated ketone to give the radical anion of the ketone and an organocopper(II) species. Subsequent transfer of an alkyl radical from the copper(II) species to the radical anion of the ketone completes the sequence (path a). Alternate mechanisms either involving no intermediate (path b) or the intermediacy of a caged radical pair (path c) are also consistent with available data.



To test for the intermediacy of caged radicals we have examined the stereochemistry of the addition of isomeric lithium divinylcuprates to α,β unsaturated ketones. The rate of isomerization of vinyl radicals is extremely rapid ($\sim 10^9$ sec^{-1}) and would be expected to lead to loss of stereochemistry in the addition products.[4] Here we report that the addition of both lithium di-cis and di-trans-1-propenylcuprate to 2-cyclohexenone is completely stereospecific.



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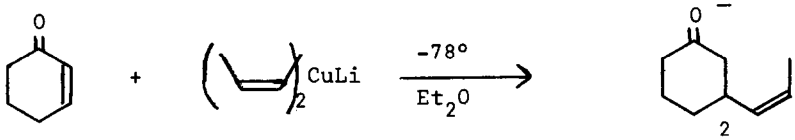

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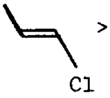
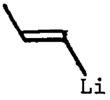
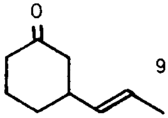
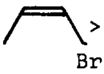
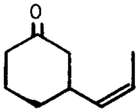
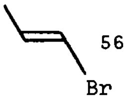
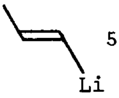
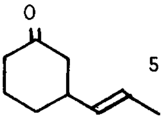
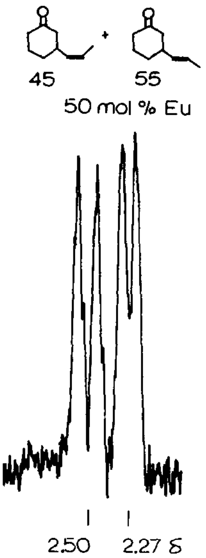
Lithium di-*trans*-1-propenylcuprate was prepared at -78° by the addition of *trans*-1-propenyllithium[5] to a suspension of copper(I) iodide in diethyl ether. 2-Cyclohexenone was added to the cuprate solution at -78°. The reaction mixture was stirred for 2 hours at -78°, warmed to 0° and quenched with aqueous ammonia-ammonium chloride buffer solution (pH ~9). The ether was removed and the residue purified by vapor phase chromatography on a 20' x 3/8" 20% SE-30 column at 145°. A similar procedure was followed for the addition of lithium di-*cis*-1-propenylcurpate[5] to 2-cyclohexenone. The results are summarized in Table I.

Table I. Addition of Lithium Dipropenylcuprate to 2-Cyclohexenone

Halide	Lithium Reagent	Ketone
 >99.5% *trans*	 98.1% *trans*	 98.9% *trans*
 >99.5% *cis*	 99.8% *cis*	 99.2% *cis*
 56.5% *trans*	 56.3% *trans*	 57.3% *trans*

The identity and stereochemistry of the products were determined from spectral data. The high resolution mass spectrum of 1 showed a parent ion of m/e 138.1044 (calculated for $C_9H_{14}O$, 138.1044; ir (CCl_4): 1710 (C=O) and 960 cm^{-1} (trans CH=CH); nmr (CCl_4): δ5.48 (2H, m, vinyl), 2.67-1.33 (9H, m, ring H), 1.65 (3H, d, J = 4.5, allylic CH_3). The high resolution mass spectrum of 2 showed a parent ion at 138.1041 (calculated for $C_9H_{14}O$, 138.1044); ir (CCl_4): 1717 (C=O), 1660 (C=C), and 713 cm^{-1} (*cis* CH=CH); nmr (CCl_4); δ5.30 (2H, m, vinyl), 2.70 (1H, m, tertiary H), 2.37-1.33 (8H, m, ring H), 1.62 (3H, d, J = 6.6, allylic CH_3). The nmr spectra in the presence of the paramagnetic shift reagent tris(dipivaloylmethanato)europium,[6] Eu(DPM)$_3$, confirmed the assigned structures. Using 50 mol % Eu(DPM)$_3$, the methyl doublets of the *cis* and *trans* isomers were completely separated (Figure 1), with the closer *cis*-methyl being shifted the greatest.



The relative amounts of compounds 1 and 2 were determined by gas chromatography on a 150' Carbowax-20M capillary column at 80°; the retention times were 37.5 min for 2 and 40.2 min for 1.

The stereospecificity of the addition of lithium dipropenylcuprate to 2-cyclohexenone provides further evidence against the intermediacy of free radicals in the conjugate additions. Furthermore, it places an upper limit of 10^{-11} sec on the lifetime of a caged radical pair since the propenyl radical has an estimated lifetime of 10^{-9} sec for inversion[4] and since less than 1% isomerization was observed. Our results are also compatible with the mechanisms of paths a and c.

REFERENCES

1. H. O. House, W. L. Respess and G. M. Whitesides, J. Org. Chem., 31, 3128 (1966).

2. H. O. House, D. D. Traficante, and R. A. Evans, ibid., 28, 348 (1963).

3. H. O. House and W. F. Fischer, ibid., 33, 949 (1968).

4. G. M. Whitesides and C. P. Casey, J. Amer. Chem. Soc., 88, 4541 (1966);

   G. M. Whitesides, C. P. Casey and J. K.Krieger, ibid., 93, 1379 (1971).

5. trans-1-propenyllithium was prepared from trans-1-chloropropene and lithium metal in ether at 0°. cis-1-propenyllithium was prepared from cis-1-bromopropene and lithium metal in ether at -28°. The isomeric purity of the lithium reagents was determined by treatment with 1,2-dibromoethane and vpc analysis of the resulting 1-bromopropenes.[4]

6. J. K. M. Sanders and D. H. Williams, ibid., 93, 641 (1971).